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SCIENTIFIC ELECTRONIC PRODUCTS, INC.
FINAL REPORT
RELIABILITY STUDY OF HC-27/U HOLDER
CONTRACT NO. DA-36-039-SC-87456
TASK NO. 3A-99-15-007-01
PLACED BY U. S. ARMY
SIGNAL RESEARCH & DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

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<p>A D Accession No.</p> <p>Scientific Electronic Products, Inc., Loveland, Colorado</p> <p>Reliability Study of Holder HC-27/U</p> <p>E. M. Shideler and Paul E. Bryan</p> <p>Final Report, 1 July 1961 to 30 December 1962</p> <p>Contract No. DA 36-039 87456</p> <p>Department of the Army Task number 3A-9915-007-01</p> <p>--- Unclassified</p> <p>ABSTRACT</p> <p>1371 HC-27/U glass holders were sealed to obtain 1000 units which did not crack after seal and which showed a glow discharge in the evacuated enclosure after thermal shock from boiling water to ice water. Examination was repeated every month for a total of twelve months, consisting of visual check for "on the shelf" cracks, thermal shock and glow discharge test for vacuum.</p> <p>All causes of failure for each month are tabulated and plotted to establish reliability with time.</p> <p>Non-uniformity and defects in parts used which are believed to have been responsible for many of the failures are discussed and recommendations for corrective measures outlined.</p>	<p>UNCLASSIFIED</p> <p>1. Reliability Study of Holder HC-27/U</p> <p>2. Contract No. DA 36-039 87456</p>
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SCIENTIFIC ELECTRONIC PRODUCTS, INC.
2303 West 8th Street Loveland, Colorado

RELIABILITY STUDY
OF
HOLDER HC-27/U

1 July 1961 to 30 December 1962

FINAL REPORT

Placed by the U. S. Army
Signal Research and Development Laboratory
Fort Monmouth, New Jersey

CONTRACT NO. DA-36-039-SC-87456

TASK NO. 3A-99-15-007-01

SCIENTIFIC ELECTRONIC PRODUCTS, INC.
2303 West Eighth Street
Loveland, Colorado

FINAL REPORT

RELIABILITY STUDY OF HOLDER HC-27/U

ELECTRONIC COMPONENTS RESEARCH DEPARTMENT

TECHNICAL GUIDELINES FOR PR & C 61-ELP/D-4212

OBJECTIVE: The object of this study is to seal sufficient enclosures HC-27/U to obtain 1000 units which, by means of a Tesla generated high frequency discharge, show a typical ionization glow discharge within the evacuated enclosure after having been subjected to the thermal shock test listed in the technical guidelines. Repeat the shock test and test for vacuum once a month for twelve months and record all data obtained to establish reliability of the holder with time.

PREPARED BY

Elbert M. Shideler and Paul E. Bryan

Contract No. DA-36-039-SC-87456

Task No. 3A-99-15-007-01

1 July 1961 to 30 December 1962

Technical Guidelines PR & C 61-ELP/D-4212

Placed By

The U. S. Army Signal Research and Development Laboratory
Fort Monmouth, New Jersey

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P U R P O S E

The purpose of this study is to establish reliability data for the glass crystal holder HC-27/U by sealing sufficient enclosures to obtain 1000 units which, by means of a Tesla generated high frequency discharge, show a typical ionization glow discharge within the evacuated enclosure after having been subjected to a thermal shock test.

The thermal shock test consists of immersion in boiling water for at least fifteen seconds and immediately thereafter, immersion in ice water for at least five seconds.

All units to be examined once a month for twelve months for the following defects.

1. Visible cracks which occurred since the last test.
2. All units given thermal shock test as above.
3. Any cracks resulting from thermal shock test noted.
4. All units not having visible cracks, tested for vacuum.

All data obtained to be tabulated and plotted and a final report written to set forth the findings and to establish, as far as possible, the causes of failure.

All in accordance with Technical Guidelines for PR & C
61-ELP/D-4212.

HEADQUARTERS
U.S. ARMY SIGNAL RESEARCH & DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

Electronic Components TECHNICAL GUIDELINES 9 March 1961
Research Department
Technical Guidelines
for PR & C 61-ELP/D-4212

RELIABILITY STUDY OF HOLDER HC-27/U

1. General:

Holder HC-27/U is a glass enclosure used in the fabrication of moderate precision quartz crystal units. Relatively small numbers of these envelopes have been assembled to date but information on the stability of crystals made with this enclosure show greatly improved performance over similar metal enclosed crystals. Because of the probable wide spread use of these improved glass enclosed crystal units and the lack of any large amount of reliability information on the life of the glass enclosure, it is necessary that a study program be put into effect quickly.

2. Detailed Requirements:

- a. Seal sufficient enclosures to obtain 1000 units which, by means of a Tesla generated high frequency discharge, show a typical ionization glow discharge within the evacuated enclosure after having been subjected to the thermal shock test listed in paragraph b.
- b. Subject each unit to a thermal shock test which consists of immersion in boiling water for at least 15 seconds and immediately thereafter, immersion in ice water for at least 5 seconds.
- c. Test each unit for a vacuum using the same equipment in (a) above.
- d. Record the number of acceptable and reject units found during (c) above.
- e. Repeat (b) through (d) monthly for a total time of 12 months.
- f. Write a final report containing all test data and a curve of failing units with time.

(1.a.)

A B S T R A C T

1371 MC-27/U glass holders were sealed to obtain 1000 units which did not crack after seal and which showed a glow discharge in the evacuated enclosure after thermal shock from boiling water to ice water. Examination was repeated every month for a total of **eleven** months, consisting of visual check for "on the shelf" cracks, thermal shock and glow discharge test for vacuum.

All causes of failure for each month are tabulated and plotted to establish reliability with time.

Non-uniformity and defects in parts used which are believed to have been responsible for many of the failures are discussed and recommendations for corrective measures outlined.

PUBLICATIONS, LECTURES, REPORTS AND CONFERENCES

There have been no publications or lectures.

Regular monthly letter type reports have been submitted.

The following conferences were held:

25th, 26th, and 27th of April 1962, Mr. E. M. Shideler and Mr. Paul E. Bryan attended the 16th Annual Frequency Control Symposium and conferences were held with Mr. Marvin Bernstein and Dr. G. K. Guttwein.

12th and 13th July 1962, Mr. Marvin Bernstein visited the Contractors plant at Loveland. The project was reviewed and methods of presenting data in the final report were discussed.

Several telephone conversations were held with Mr. Marvin Bernstein.

FACTUAL DATA

A total of 1250 bases and covers HC-27/U were received as furnished by the Government. 450 of these parts were obtained from one source and 800 from another.

The parts from both sources were defective in many respects. The covers were not of uniform size and shape, the wall thickness varied greatly and the edges were in many cases, uneven, chipped and cracked. The bases were likewise, non-uniform in size and shape and thickness varied widely. The amount of glass frit applied over the Kovar ring also varied greatly.

The combination of these defects and variations made it extremely difficult to position the parts properly in the sealing head.

The sealing head used at the time these units were sealed depended on time and power to determine a proper seal. All of the deviations mentioned above made it almost impossible to maintain the proper amount of squeeze down to get a good glass to glass seal both inside and outside the Kovar ring. It seems to be essential to have this fusion of the glass of the cover with the glass base to form a good meniscus both inside and outside the metal Kovar ring in order to assure that the parts will not crack later.

Because of these factors, it was necessary to seal 1371 parts to obtain the required 1000 good vacuum tight enclosures after the initial thermal shock test.

Since the Government had furnished only 1250 parts, the Contractor voluntarily furnished 121 additional units at no cost to the Government. The casualty rate of 27% for seal up and first thermal shock would seem to indicate that the holder and process were not feasible but much better results had been experienced by the Contractor in several months preceeding these tests. However, for production purposes, all parts were 100% inspected and approximately 50% were being rejected. The casualty rate for production averaged only about 10% and if enough parts had been available to carry out such an inspection, it is certain that the over-all results would have been considerably better.

Since these units were sealed, the various manufacturers of the parts for the HC-27/U holder have improved the quality and uniformity of the product a good deal but 100% inspection of incoming parts is still considered necessary. Photographs which follow, show some of the defects which cause failures and also, show parts which will produce a good seal.

Some essential factors are as follows:

1. The glass bases should be of uniform thickness and size.
2. The raised land on top of the base should be uniform in height and shape so that it will fit the cover well enough to automatically position the cover when it is placed over the land.
3. The base must have fairly square outside shoulders that show a rim of glass outside the Kovar ring.

4. The Kovar ring should be pressed down into the base so that it is flush with the glass all around.
5. While it is possible to make good seals without any glass frit over the Kovar ring, it seems desirable to have a very thin layer of frit over the Kovar. This protects the metal from contamination and oxidation and, in melting, wets the edge of the cover and helps the seal to reach flow point temperature more quickly. Too much frit, however, will bubble and out-gas and may be sufficiently porous to cause slow loss of vacuum.
6. The covers should be uniform in shape and of uniform wall thickness. The inside shape should fit the land on the base sufficiently well to be self aligning.
7. The outside of the cover must never be so large that any part of the periphery will extend beyond the base as it is absolutely necessary that a smooth meniscus be formed all the way around the seal on the outside as well as inside.
8. The lip of the covers must be flat so they will contact the base evenly all around and be free from chips and cracks.
9. It is possible that some vacuum failures were due to leaks around the pins in cases where the bases were not fired at a high enough temperature or the pins were not pre-beaded with glass before forming the base.

The other factor which causes poor seals is the use of a programmed time and power sequence to regulate the amount of squeeze down. Since glass parts at their best will be somewhat non-uniform, and since the amount of squeeze down must be closely controlled in order to produce a good meniscus around the seal area both inside and outside the Kovar ring, a sealing head has been developed which automatically controls this squeeze down and cuts the power to the work coil when a correct seal has been made. It has been found that using this process, with the power level held constant, and just high enough for the temperature to reach the flow point of the glass, that even using carefully inspected parts, the time required to make a good seal varied from 40 to 120 seconds.

By using the improved sealer and inspecting parts 100%, production losses have been reduced to approximately 3 or 4% and failures in the field have been reduced to almost zero.

The following charts and tables show the monthly failure rates of the holders sealed for this study over a period of twelve months and whether the failure was due to on the shelf visible cracks, since the previous inspection, loss of vacuum for causes not visible, or cracks which occurred during thermal shock in the current monthly evaluation.

The 95% confidence limits at the end of eleven months are 40,136 hours to 30,102 hours.

It is interesting to note that of the total of 194 failures over the 12 month period, the largest number (86) were visible cracks that developed on the shelf between inspections. The next largest number failing (72) were due to loss of vacuum without visible cracks or defects, and the smallest number (36) occurred in the thermal shock test. This would seem to indicate that the thermal shock test does not give a very good indication of the reliability of the holder.

In more recent production, our sealed units are subjected to a much more severe shock test from boiling water into dry ice and alcohol near the temperature of dry ice and only 3 to 4% fail this test and, while we have no accurate statistics on later failures, returns from customers indicate that no serious problem exists and that careful inspection of glass parts plus proper semi-automatic sealing methods will insure good reliability.

CONCLUSIONS

It is believed that the following conclusions can be reached from this study.

1. In spite of the poor showing made by the units tested in this study, most of the failures can be attributed to non-uniform and defective parts and to the fact that the sealing head did not provide for precise control of the degree of squeeze down.
2. It seems apparent that if the following precautions are observed, the HC-27/U holder can be sealed with excellent yields.
 - a. All parts inspected before use.
 - b. Sufficient power applied to the work coil to bring the glass parts to the flow point in about 60 seconds.
 - c. Use a controlled push down device that will cut the power to the work coil when a push down of approximately .025 to .030 inches has been reached.

RECOMMENDATIONS

1. Complete specifications should be written to tie down all parameters of the glass parts including materials, dimensions, shape factors, amount of frit applied and requiring pre-beading of pins and/or wires to insure a good wetting of the pin to base seal.

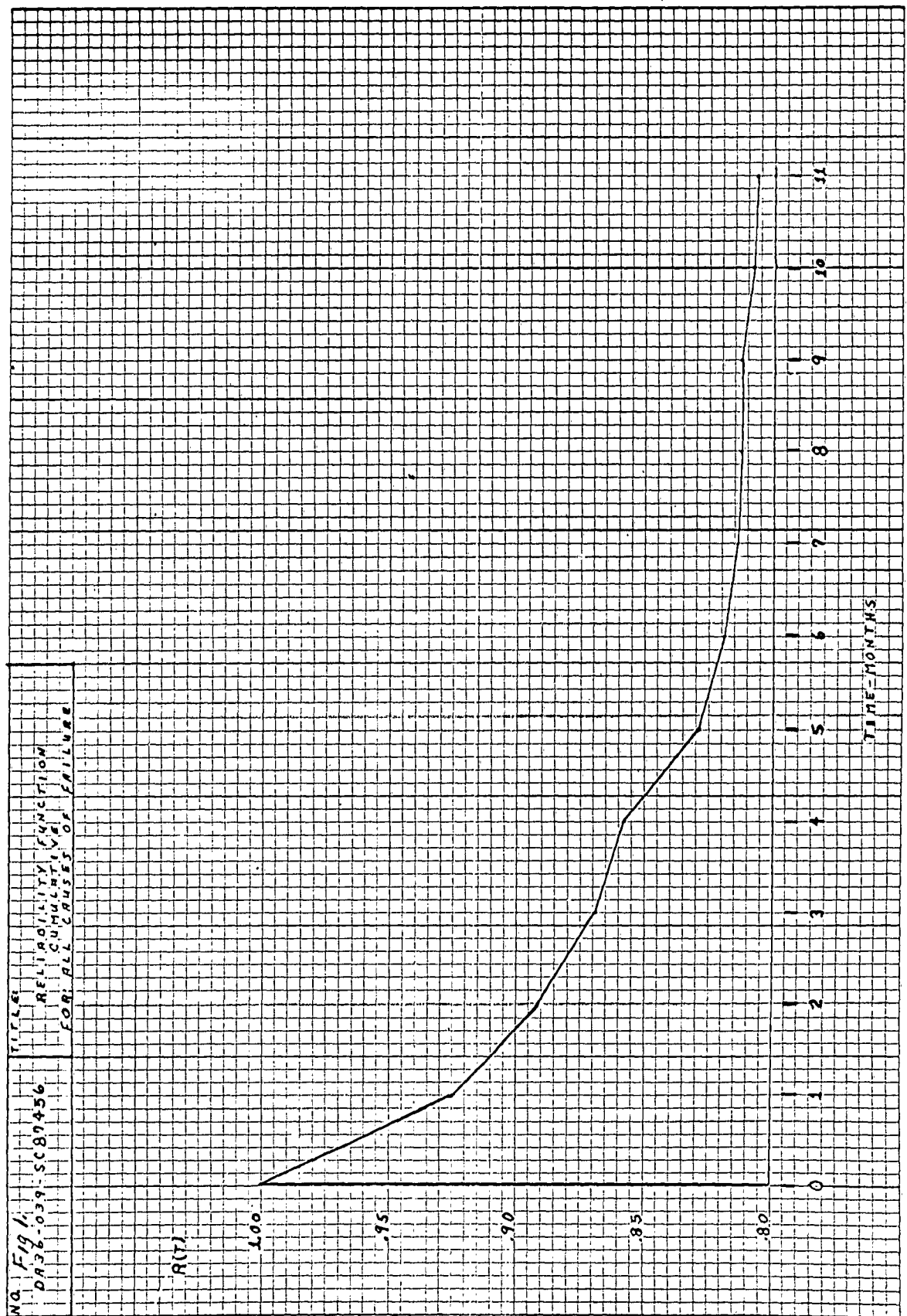
2. Another study should be initiated using possibly a larger number of units all of which have been inspected for uniformity and defects. Sealing should be done in the new type sealing head where squeeze down can be precisely controlled automatically. The method of testing should be the same except possibility of a more severe thermal shock test.

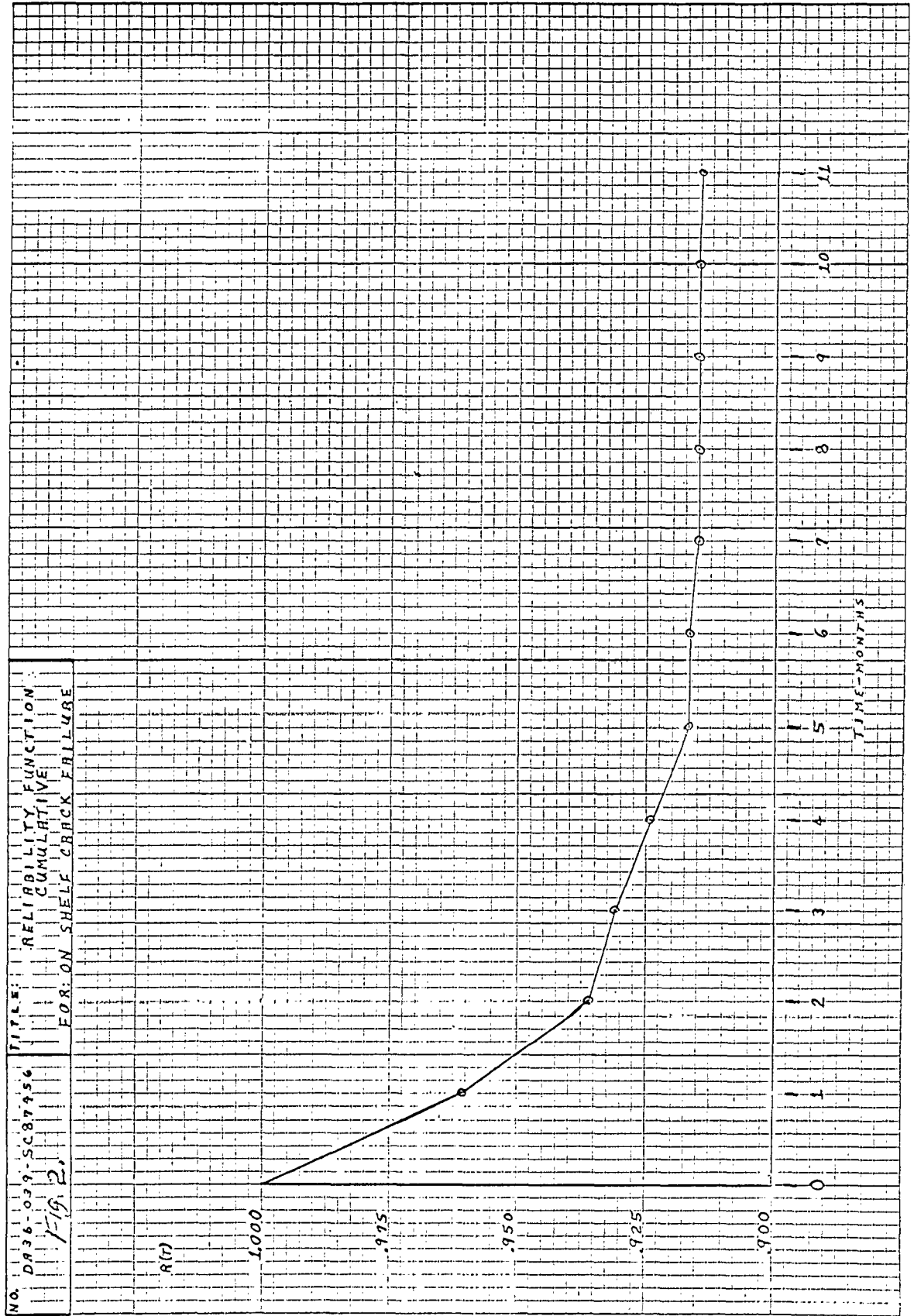
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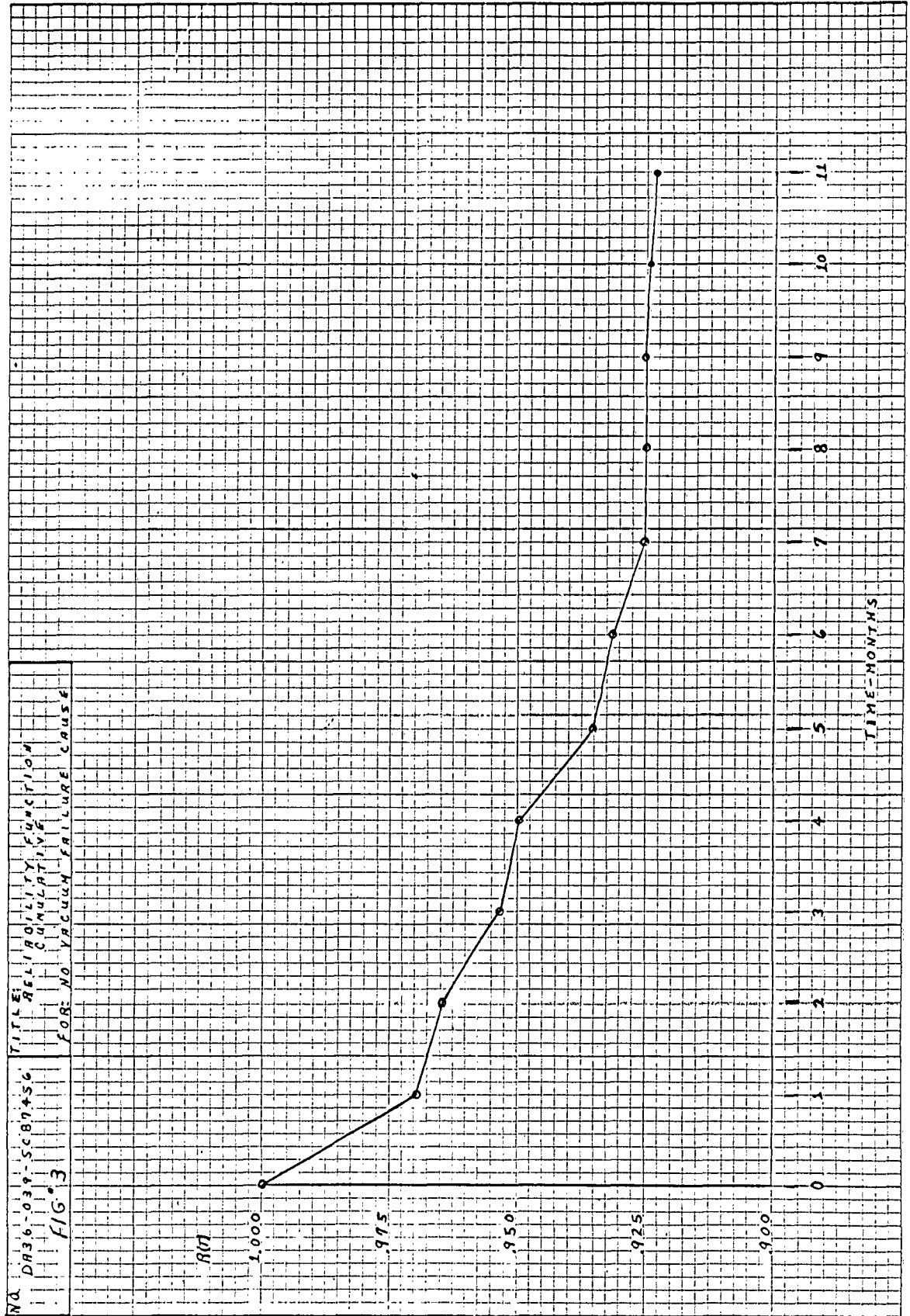
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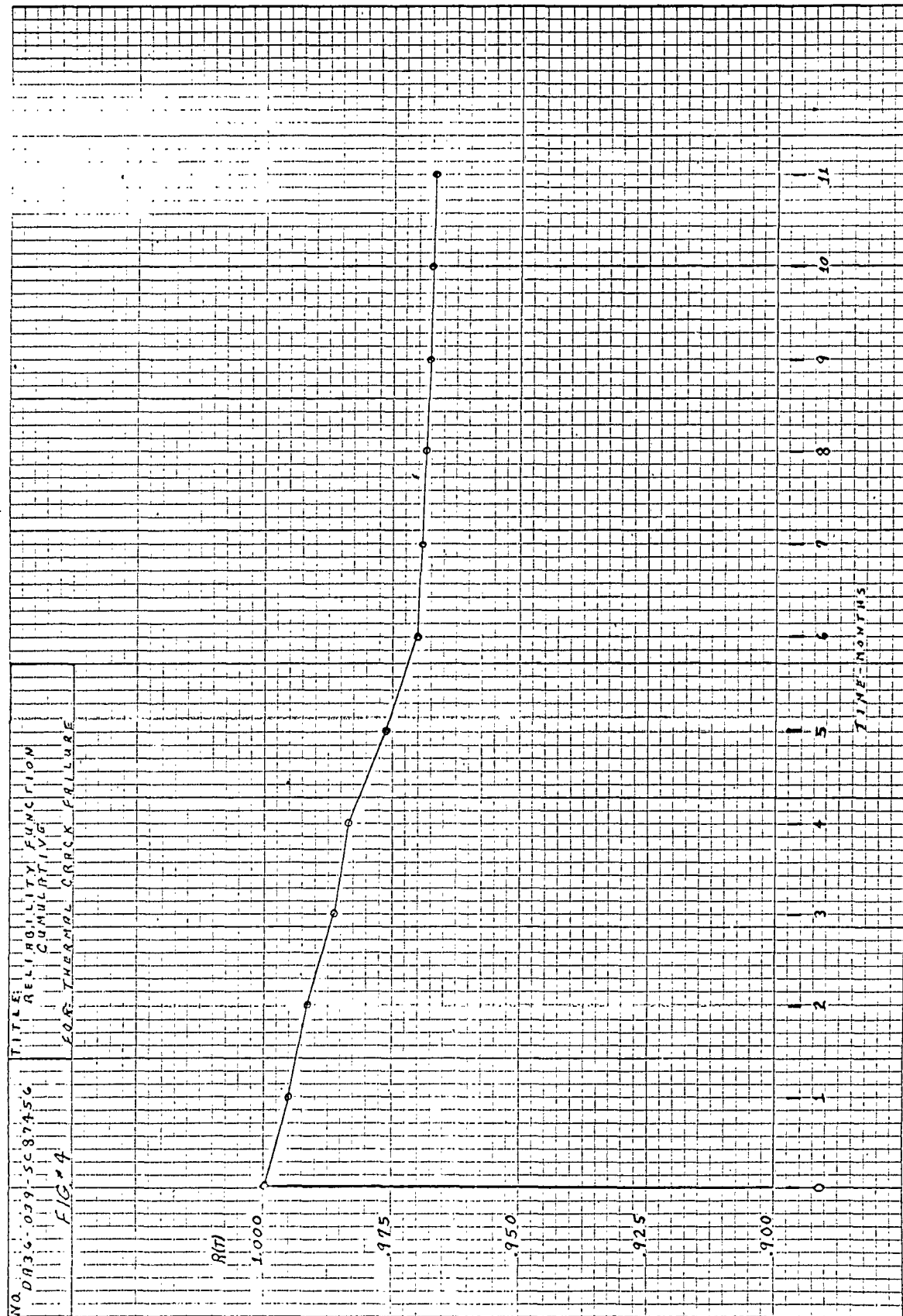
SIGNAL CORPS CONTRACT DA-36-039-SC-87456
TABLE NO. 1

Date	No Vacuum	On Shelf Cracked	Thermal Cracked	Balance Good
3/14/62	31	39	5	925
4/17/62	5	25	4	891
5/14/62	11	8	4	868
6/13/62	3	5	4	856
7/13/62	15	5	7	829
8/21/62	4	0	6	819
9/14/62	1	3	2	813
10/15/62	0	0	1	812
11/16/62	0	0	1	811
12/17/62	2	1	1	807
1/20/63	<u>0</u>	<u>0</u>	<u>1</u>	806
TOTAL FAILURES	72	86	36	









NO.

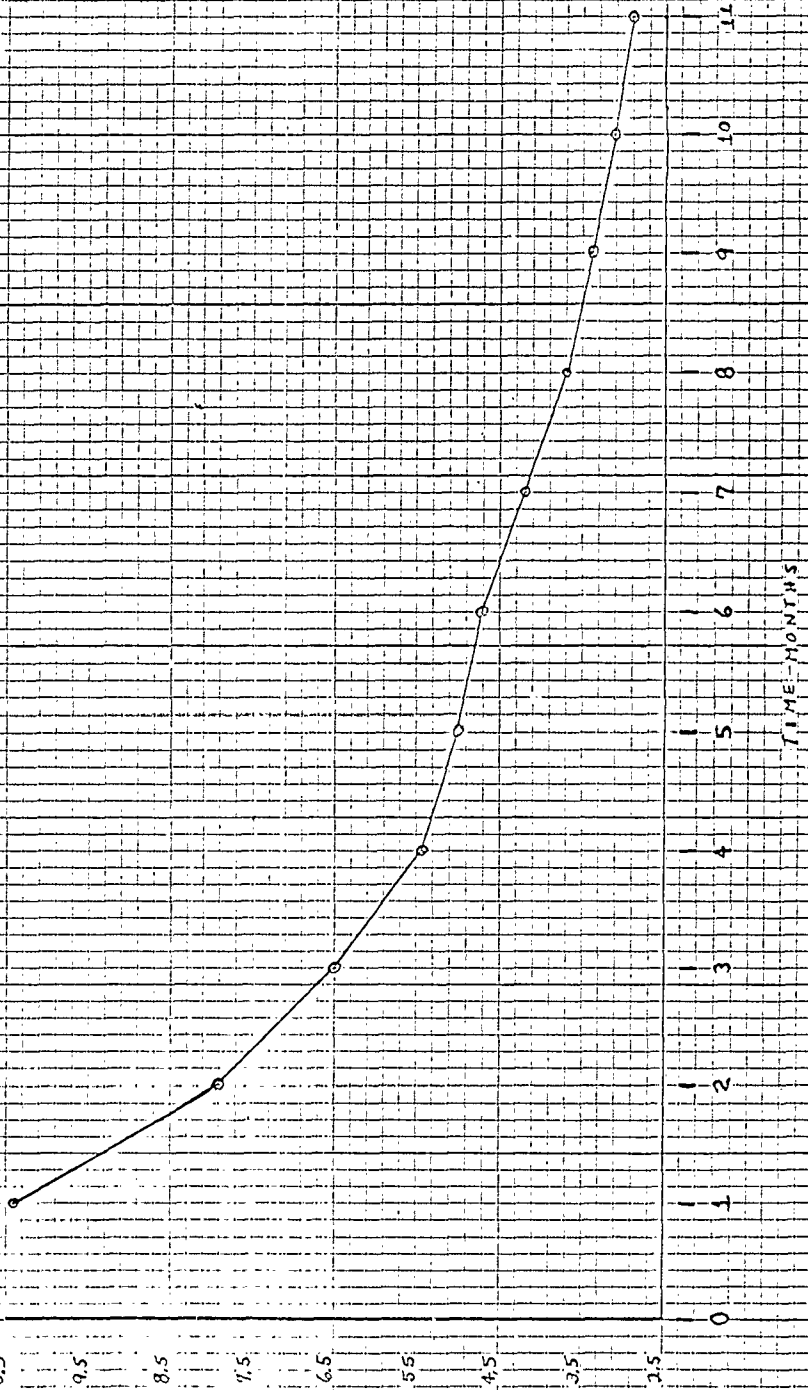
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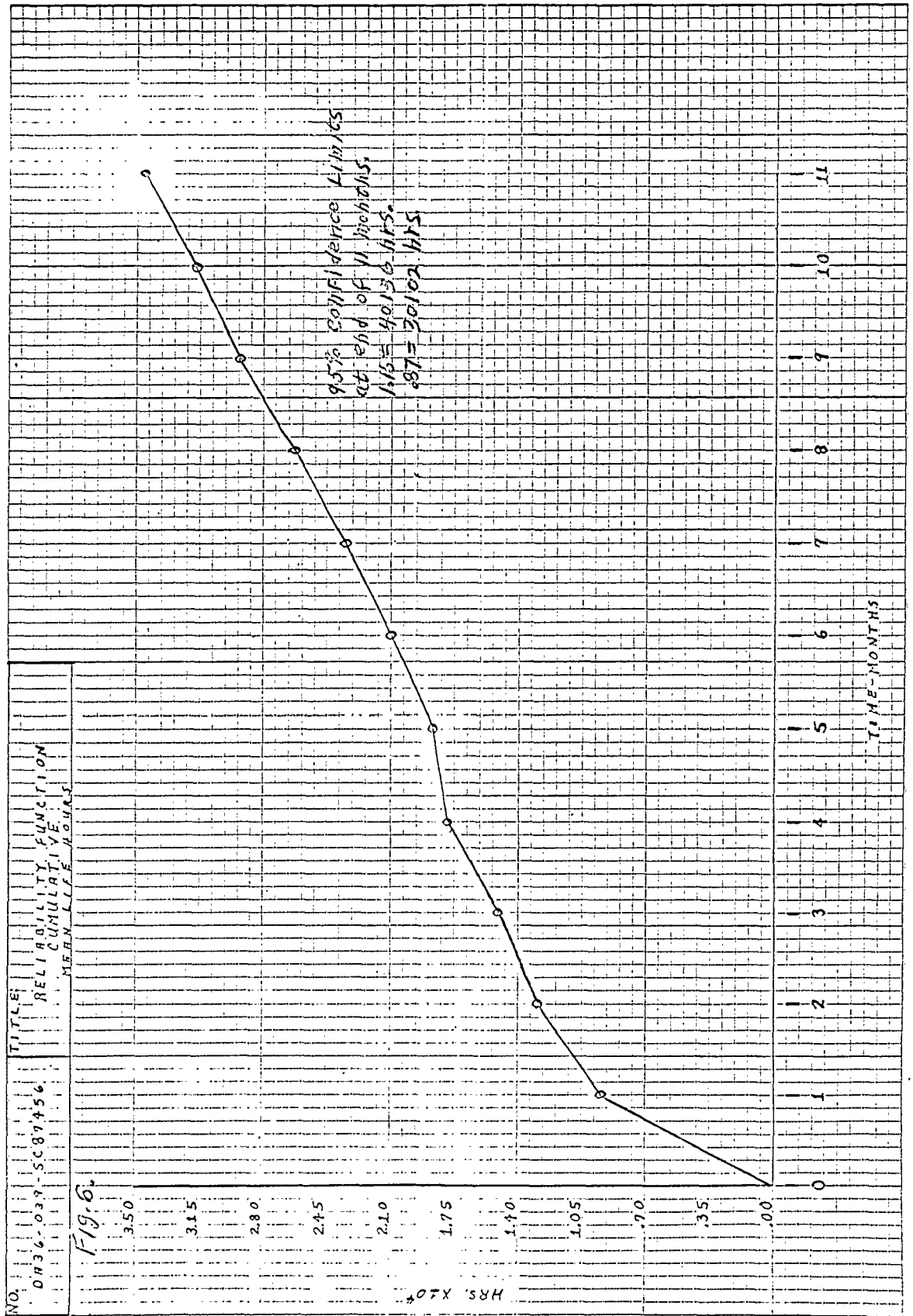
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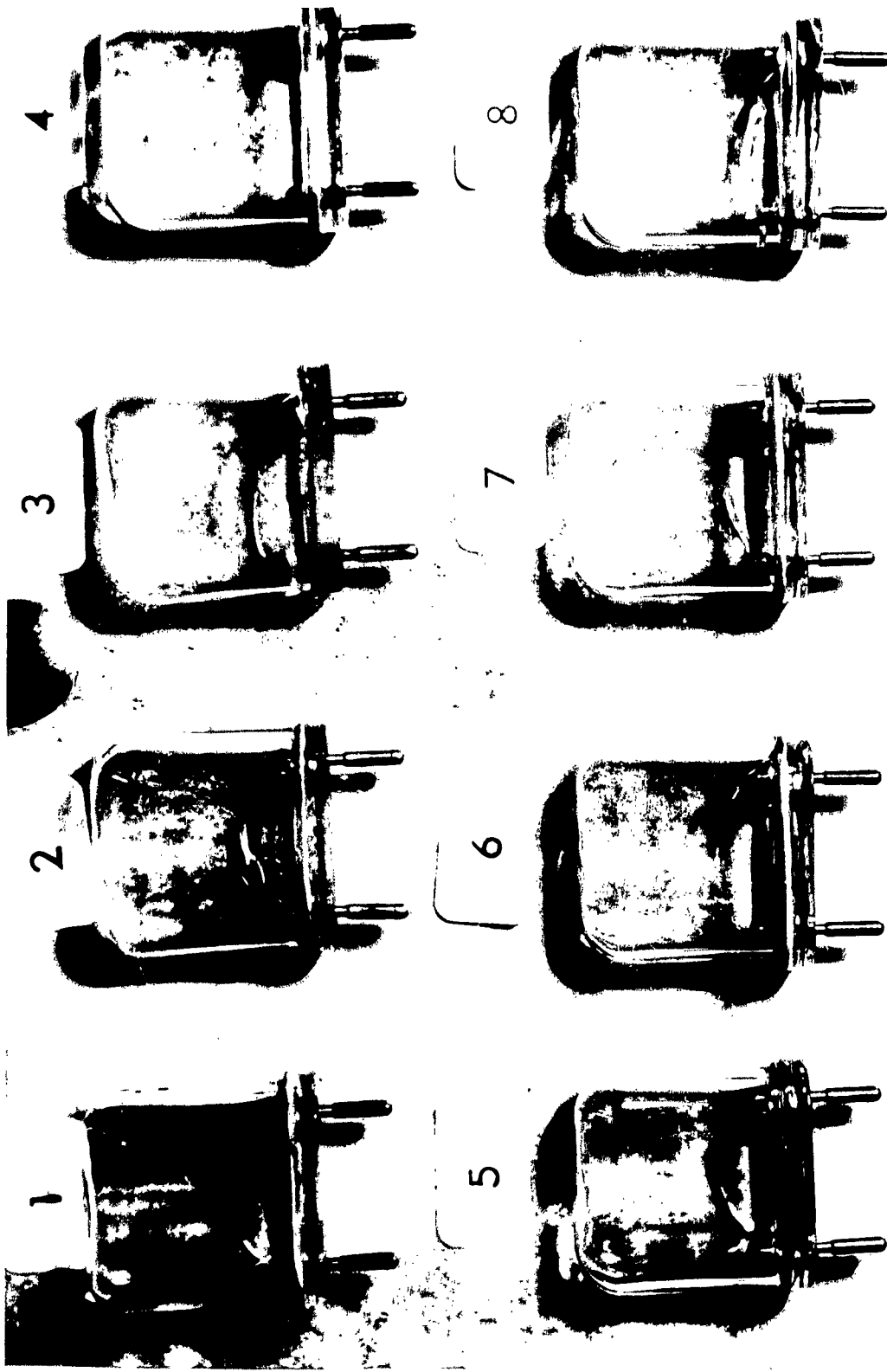
RELIABILITY FUNCTION
CUMULATIVE
FAILURE PER 1,000 HOURS

F-19.5

PER CENT
FAILURE
PER 1,000 HRS







19

Fig 7

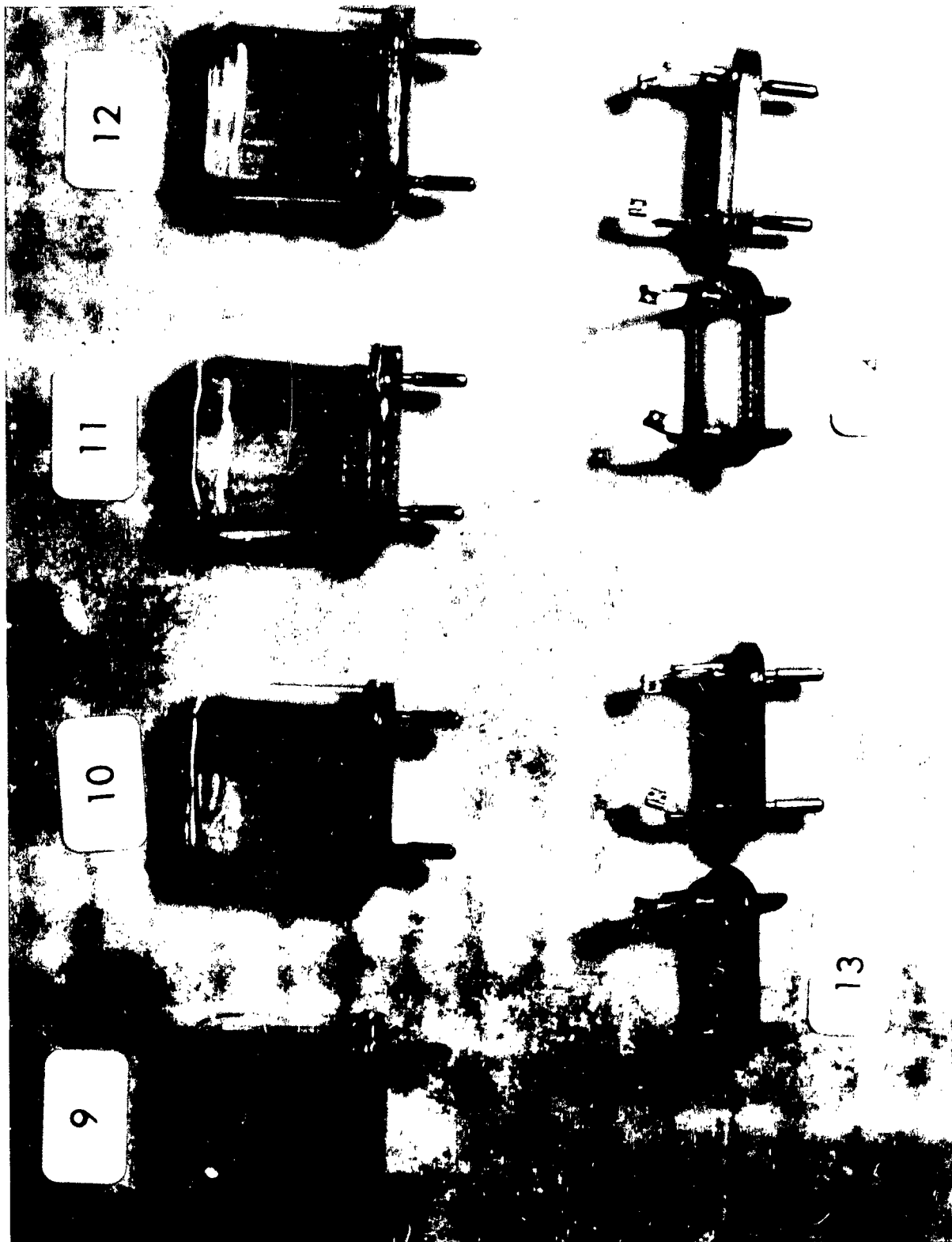


Fig 8

EXPLANATION OF PHOTOGRAPHS

FIGURE 7: Holders number 1, 2, 3, 5, 6, 7 and 8, show cracked holders due to poorly aligned parts, covers too large, and too much frit.

Holder number 4 appears to be a good seal but lost vacuum possibly because of too much frit or leaking around the pins.

FIGURE 8: Holders number 9, 10, 11 and 12 show good vacuum tight seals. Note the good alignment of parts, good meniscus all the way around and absence of excessive frit.

Number 13 shows two views of unsatisfactory bases. The glass rounds off outside the Kovar ring making it impossible to get a good glass to glass meniscus. Number 14 shows good bases with square shoulders and well defined land which makes alignment of parts automatic.

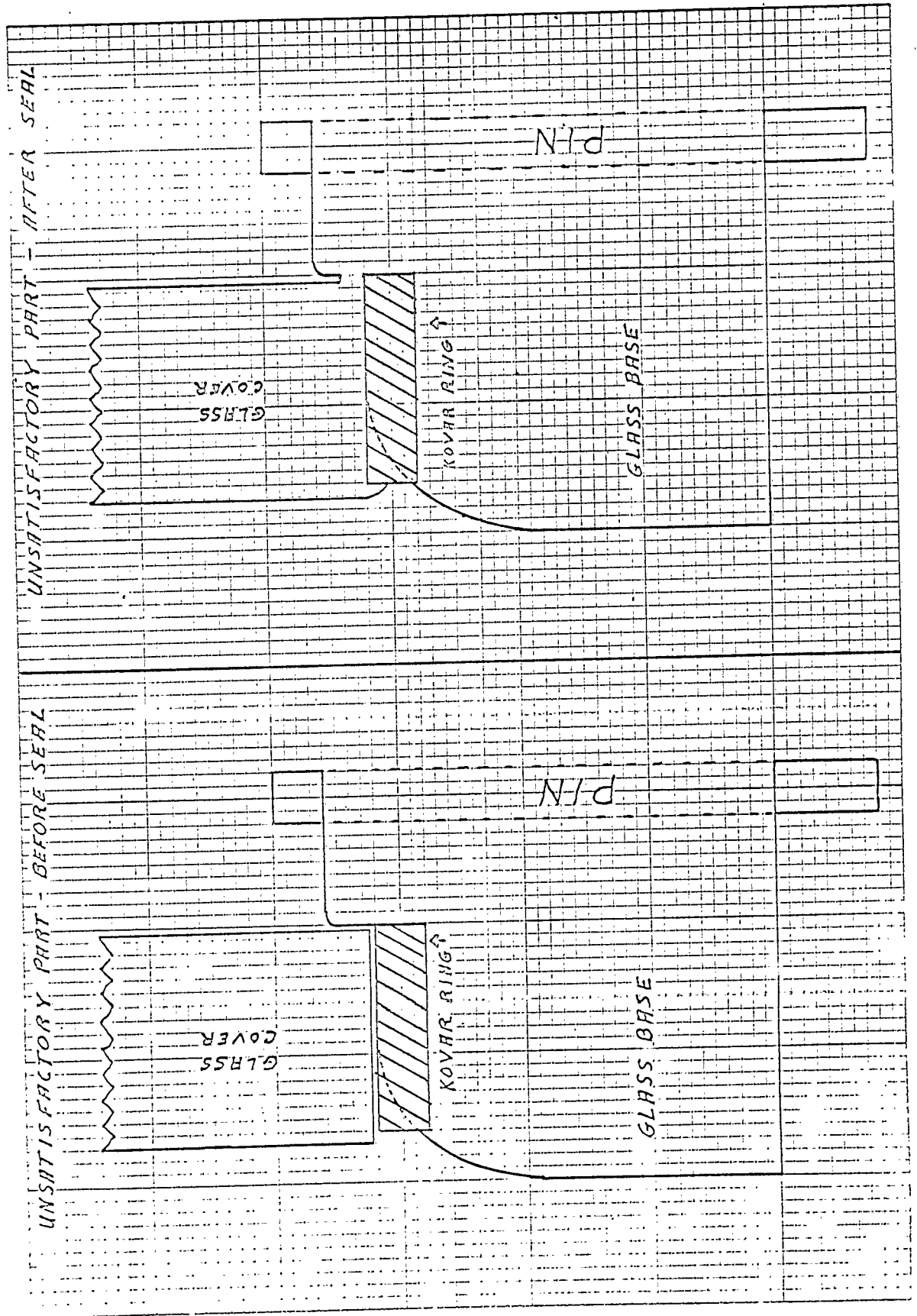


Fig. 9

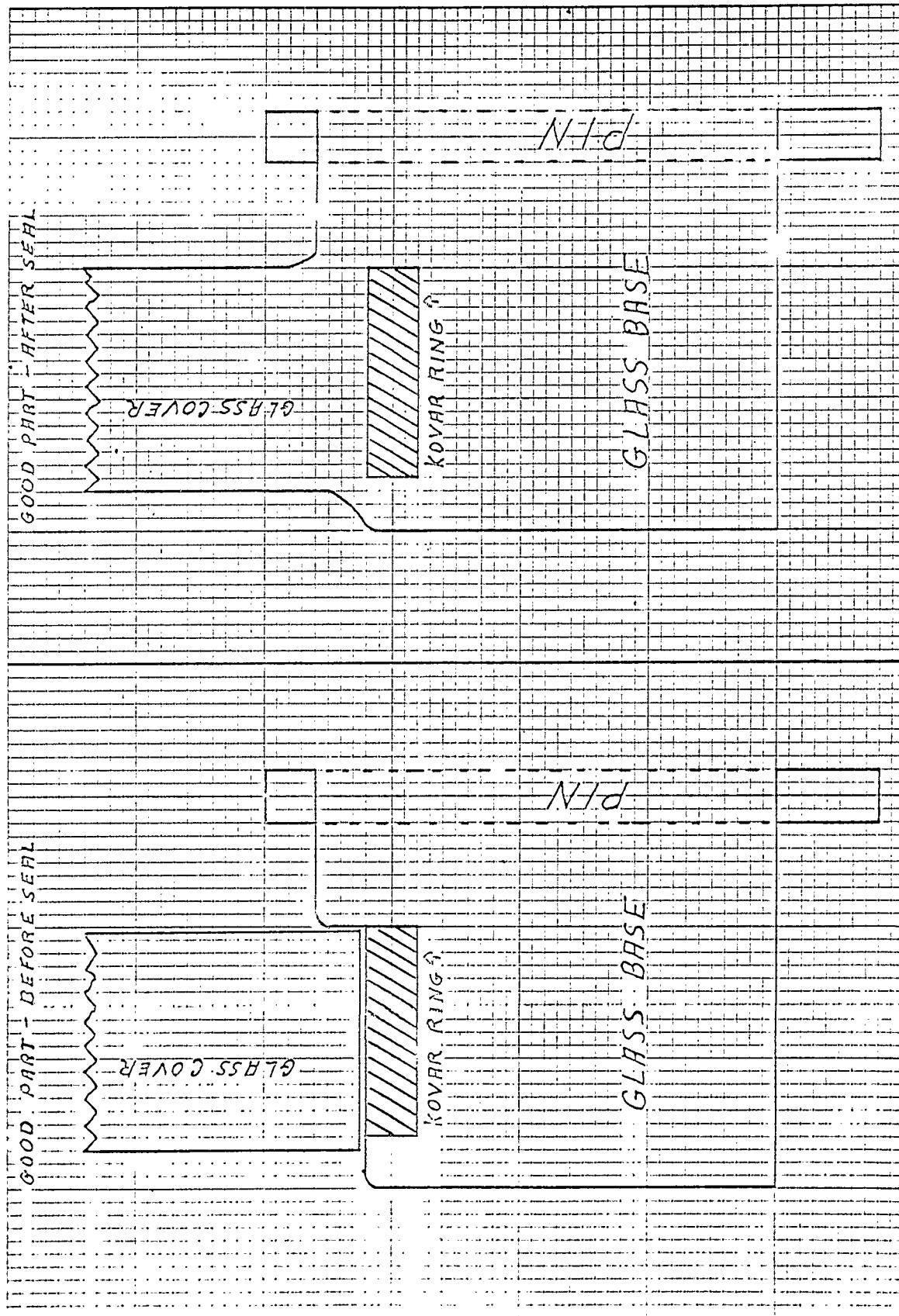


Fig. 10

IDENTIFICATION OF PERSONNEL

E. M. SHIDELER, CHIEF ENGINEER	290 HOURS
WAYNE HASTINGS, ENGINEER	73 HOURS
SEALER OPERATORS - TECHNICIANS	184 HOURS
OFFICE PERSONNEL (TYPING, PRINTING ETC.)	<u>48 HOURS</u>
TOTAL HOURS	595 HOURS

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ATTN: SELRA/PF, Technical Staff		Mount Holly Springs,	
(Record Copy)	1	Pennsylvania	1
ATTN: SELRA/TN	3	Mr. L. McCoy	

This contract is supervised by the Solid State and Frequency Control Division, Electronic Components Department, USAELRDL, Fort Monmouth, New Jersey. For further technical information, contact the Project Engineer, Mr. Marvin Bernstein, Telephone 535-1978 (New Jersey Area Code 201).